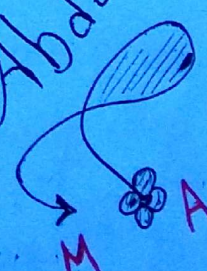


Challenge is difficult

The Failure in it
is more difficult

Abdo.

A small drawing of a flower with a lightning bolt and the letter A.

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1 Function of Respiratory system

① Respiratory function (uptake of O_2 from atmosphere to tissue and remove CO_2 from tissue to atm)

② Non-Respiratory function

1- breathing movement affect The rate of (Venous return)

2- Excretion of waste products e.g. acetone and alcohol

3- Excretion of water vapour

4- regulation of pH

5- regulation of temperature

6- preception of (smell sensation)

7- (Vocalization) by suppling air to larynx

8- providing many (protective mechanisms)

9- Lungs perform several functions

1- secrete The surfactant

2- secrete heparin

3- Synthesize prostaglandins and histamine

4- remove bradykinin and serotonin from The blood

5- Convert Angiotensin I to II

2 Cough and Sneezing reflexes

* Cough reflex

* definition (It is protective reflex initiated by irritation of The larynx & Trachea & bronchi)

* The stimulus excites certain mucosal irritant receptor That discharge signals via afferent vagal nerve fibers to respiratory centers in brain stem Leading to coughing

⇒ Coughing start by

① short inspiration Then The glottis is closed by epiglottis and approximation of The vocal cords

② occur forced expiration which increase The pressure of The trapped air in The lungs

③ The glottis is opened suddenly So air in The lungs is expelled at high velocity

* Sneezing reflex

* definition (It is protective reflex initiated by irritation of the nasal mucosa)

* The stimulus excites certain nasal irritant receptors that discharge signals via afferent trigeminal nerve fibers to the respiratory centers in the brain stem leading to sneezing

⇒ Sneezing starts by

① short inspiration followed by forced expiration while the glottis is kept open

② The rapidly moving expired air expels the irritant substance in the nasal passage outwards

3 Lung surfactant

* definition (It's the chemical substance secreted by Type II epithelial cells and it consists of dipalmitoyl-phosphatidyl choline and other protein and lipid)

* The effectiveness of the lung surfactant in reducing the fluid surface tension depends on 2 factors

1- The total surface area of the fluid

2- The density of the surfactant at the fluid surface

* Function of the lung surfactant

1- It increases the distensibility and decreases the recoil force of the lung.

2- It reduces the work of breathing by facilitating inspiration.

3- It equalizes the pressure in the smaller and larger alveoli.

4- It maintains alveolar stability

5- It prevents pulmonary edema

6- It has immunological function

* Factor affecting formation of surfactant

⇒ Factors that stimulate formation (Thyroid hormone / glucocorticoid hormone)

⇒ Factors that inhibit formation (smoking / insulin) (↑ free radical)

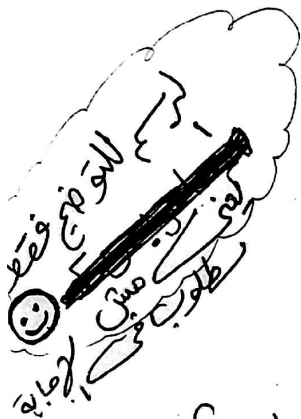
Intra - pleural pressure (IPP) ~~IPP~~

- definition (The pressure inside Thoracic cavity)

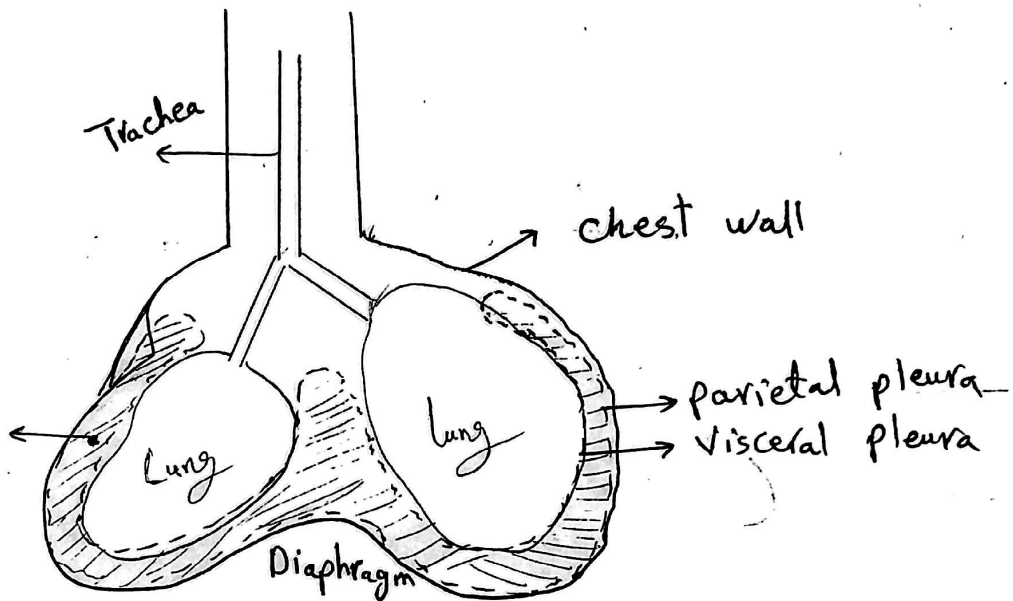
Volume -3 or 757 Less Than atmospheric pressure 0 or 760
Thus called subatmospheric pressure

* Cause of Negativity of IPP

- ① expansion of both alveoli and Thoracic cage
→ Thoracic cage and parietal pleura direct outside and alveoli and visceral pleura direct inside Thus distention between parietal and visceral pleura ↑ but content is constant
- ② Rate of growth of hard tissue in Thoracic cage increase about (it) in alveoli
→ Thus Thoracic cage enlarge with parietal pleura and alveoli enlarge with visceral pleura Thus the distention between them ↑ but content is constant



Fluid
act as
1- lubricant
2- glu



* importance of The negative IPP

- 1- It prevents collapse of The lung During expiration
- 2- It helps expansion of The lung During inspiration
- 3- It helps venous return and lymphatic return
- 4- It is measurement of elastic recoil of The lung
- 5- It increase blood flow in pulmonary vessels
- 6- It helps lymph flow from extra to intrathoracic vessels

5 Dead space (DS) bas case

* definition (This is the space in the respiratory system occupied by gas that doesn't exchange with blood)

* Types

- ① Anatomical DS
- ② Alveolar DS
- ③ Physiological DS

1 Anatomical DS

def * This is the area in which gas exchange doesn't normally occur

* It extends from the nose down till the respiratory bronchioles

* Its volume is normally about 150 ml

2 Alveolar DS

def * It is volume of air in the inactive alveoli

* Alveoli become inactive when their blood supply is blocked

* There is ~~no~~ alveolar dead space in a normal healthy person

3 Physiological DS

def * It is the volume of air in the respiratory system

* It doesn't take part in gas exchange with blood

* $\text{physiological DS} = \text{Anatomical DS} + \text{Alveolar DS}$

(In the normal healthy person) The physiological and anatomical DS are identical

⇒ There is Dead space ventilation

* definition (It is the part of the respiratory minute volume which doesn't reach the alveoli)

* important role of DS

1- protection of alveoli

2- Sensation

3- Vocalization

4- Wasted ventilation

Lung Volumes and Capacities

* Lung Volumes

- ⇒ The lung volumes are measured when the lung is in the mid-thoracic
- ⇒ Their values normally vary with age and being 20-25% less in females

⇒ The various lung volumes are the following:

1 Tidal Volume (TV)

(This is volume of air which can be inspired and expired in respiratory cycle during rest. It is about 0.5 liter)

2 Inspiratory Reserve Volume (IRV)

(This is the volume of air which can be inspired by maximum inspiration after normal inspiration. It is about 3 liters)

3 Expiratory Reserve Volume (ERV)

(This is the volume of air which can be expired by deep expiration. It is about 1 liter)

4 Residual Volume (RV)

(This is the volume of air that remains in the lungs after deep expiration. It cannot be expelled out except after opening the chest and collapse of the lung. It is about 1.5 liters)

5 Minimal Volume

(This is a small volume of air that cannot be expelled out even after opening the chest and collapse of the lungs. It is about 150 mL)

* Lung Capacities

* definition (The combination of two or more of lung volumes)

⇒ The various lung capacities are the following:

1 Inspiratory Capacity (IC)

(It is the maximal volume of air that can be inspired after normal expiration. It equals $TV + IRV = 3.5$ liter)

2] Expiratory Capacity (EC)
(It is maximal volume of air which can be expired after normal inspiration)

It equals $Tv + ERV = 1.5$ Liters

3] Residual Capacity (Functional Residual Capacity (FRC))
(It is The volume of air remaining in The Lung after normal expiration)

It equals $ERV + RV = 2.5$ Liters

4] Vital Capacity (Vc)

(It is The volume of air given out by maximum expiration after maximum inspiration)

It equal $Tv + IRV + ERV = 4.5$ Liters

5] Total Lung Capacity (TLC)

⇒ It is The maximum volume of air Contained in The lungs

⇒ It equal all The Lung volumes

$Tv + IRV + ERV + RV = 5.7$ Liters

7] Pulmonary Function tests 6 Types

1] Tests of Lung volumes and Capacities

⇒ These include 1- The vital capacity 2- IRV
3- The residual volume 4- ERV

2] Tests of The power of The Respiratory muscles

⇒ These include 1- The vital capacity
2- The maximum breathing capacity

3] Tests of Airway resistance

⇒ These include 1- vital capacity 2- (RV) 3- The peak expiratory flow

4] Tests of The integrity of alveolo-capillary membrane

⇒ These include 1- Measurement of alveolar venous and arterial (Po_2) and (PCO_2)
2- " " " " (PH)

5] Tests of The patency of Airways

⇒ These include 1- Measurement of Arterial blood gases 2- X-ray

6] Tests of The Functional Reserve of The respiratory system

⇒ These include 1- BR test 2- dyspneic index

Mechanism of inspiration and Expiration

* Inspiration

→ The normal resting inspiration is brought by contraction of The main muscles of inspiration as follows:

- 1. The contraction of The diaphragm Lead to
 - * displaces its dome downwards about 1.5 cm and
 - * increase The vertical diameter of Chest cavity.
- 2. The contraction of The external and intercostal part of The internal Intercostal muscles Lead to
 - * Elevation of The ribs → This increase The antero-posterior diameter of The chest
 - * Eversion of The ribs → This increase The side-to-side diameter of The chest

→ In Forced inspiration, The main muscles of inspiration contract more forcibly and accessory muscles of inspiration

- e.g
- 1- Sternomastoids
 - 2- scaleri
 - 3- quadratus Lumborum
 - 4- serratus posterior inferior fix The lower ribs

* Expiration

→ The normal resting expiration is passive process brought about by (elastic recoil of The Lungs)

- * (No) muscles of expiration are needed during normal resting expiration

→ The forced expiration is produced by

- 1. Contraction of The accessory muscles of expiration i.e internal intercostals which lowers The ribs

- 2. Contraction of The abdominal wall muscles

- Lead to
- * ↑ The intra-abdominal pressure
 - * elevates The diaphragm up into The Thoracic Cavity

9 Regulation of respiration (Nervous & chemical)

(A) Chemical regulation of respiration

1 The effect of P_{CO_2}

(hypercapnia) $\uparrow P_{CO_2} \longrightarrow \uparrow$ stimulate The respiratory center

2 The effect of P_{O_2}

(hypoxia) $\downarrow P_{O_2} \longrightarrow \uparrow$ stimulate " " "

3 The effect of pH

(acidosis) $\longrightarrow \uparrow$ stimulate " " "

while opposite changes in these effects inhibit it

Such effects occur by stimulating 2 type chemoreceptors

1 Central chemoreceptor

- They found at the ventrolateral surface of the medulla
- They are stimulated by hypercapnia but indirect while stimulated by H^+ → direct
- They are insensitive to hypoxia
- They are responsible for 30% of the ventilation response to hypercapnia

2 Peripheral

- 2 type
 - 1 Carotid Bodies
 - 2 Aortic Bodies

⇒ They sensitive to hypoxia

⇒ They Less sensitive to H^+ and hypercapnia

⇒ They are responsible for 100% of the response to hypoxia

⇒ " " " " 20% of the response to hypercapnia

Nervous (non chemical) Regulation

Effect of high brain centers

- 1- The motor cortex can voluntarily stimulate OR inhibit
- 2- The limbic system stimulates breathing during emotions
- 3- The hypothalamus stimulates breathing during alarm response
- 4- The cerebellum stimulates by movement during exercise

Effect from Lung receptors

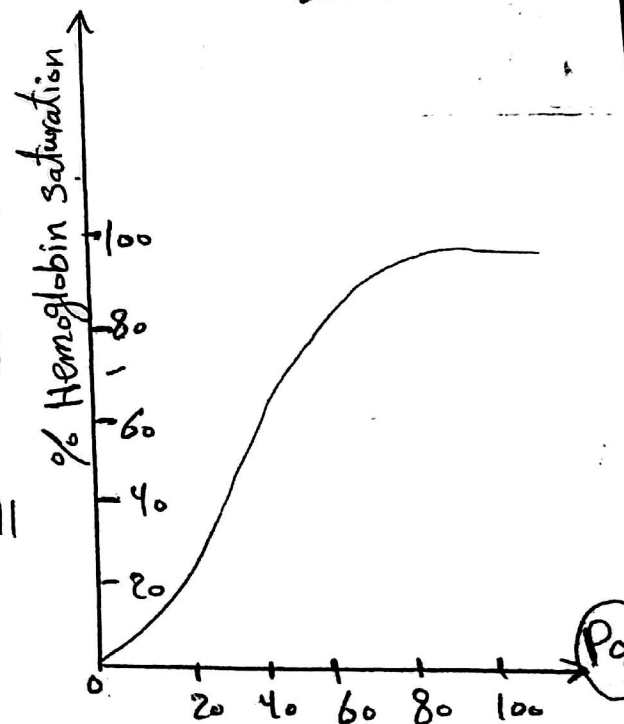
- 1- From inflation and Deflation Receptors
 - ⇒ inflation reflex → shortens inspiration and prolongs expiration
 - ⇒ Deflation reflex → shortens expiration and prolongs inspiration
- 2- From irritant receptor
 - ⇒ in the nose produces sneezing
 - ⇒ in the trachea OR bronchi produces coughing
- 3- From J- receptor
stimulation of (juxta capillary receptor) by chemical substance

Reflexes from other receptor in the body

- 1- From swallowing receptor
- 2- From mechanoreceptor in the chest muscles
- 3- From limb muscles
- 4- From arterial baroreceptors

O₂ dissociation curve ~~Expt~~

- 1 At P_{O_2} of 95 mmHg, hemoglobin is almost fully saturated with O_2 (97%)
- 2 At P_{O_2} of 70 mmHg, hemoglobin is still saturated with O_2 (93%)
- 3 At P_{O_2} of 40 mmHg, hemoglobin is still saturated with O_2 (75%)
- 4 At P_{O_2} of 30 mmHg, hemoglobin is still saturated with O_2 (55%)



⇒ Factors That shift The O_2 -Dissociation Curve to The right

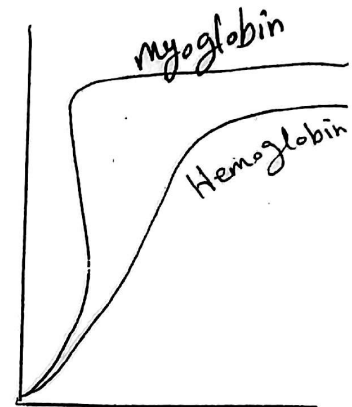
- 1- $\uparrow P_{O_2}$
- 2- $\downarrow$ in pH
- 3- $\uparrow$ of temperature
- 4- $\uparrow$ in 2-3 Diphosphoglycerate

⇒ Factors That shift The O_2 -Dissociation Curve to The left

- 1- $\downarrow P_{O_2}$
- 2- $\uparrow$ in pH
- 3- $\downarrow$ temperature
- 4- $\downarrow$ 2-3 DPG
- 5- CO poisoning
- 6- Anemia

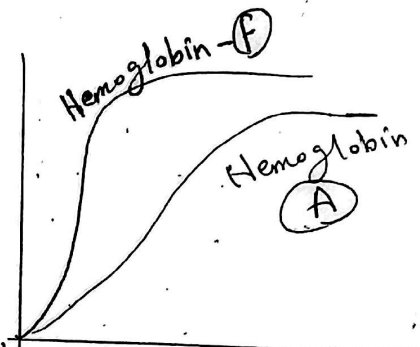
⇒ The O_2 -Dissociation Curve of Myoglobin

- * The importance of Myoglobin as (O_2 supplier to muscles)
- * It appears only at low P_{O_2}
- * 2-3-DPG doesn't affect Myoglobin affinity to O_2



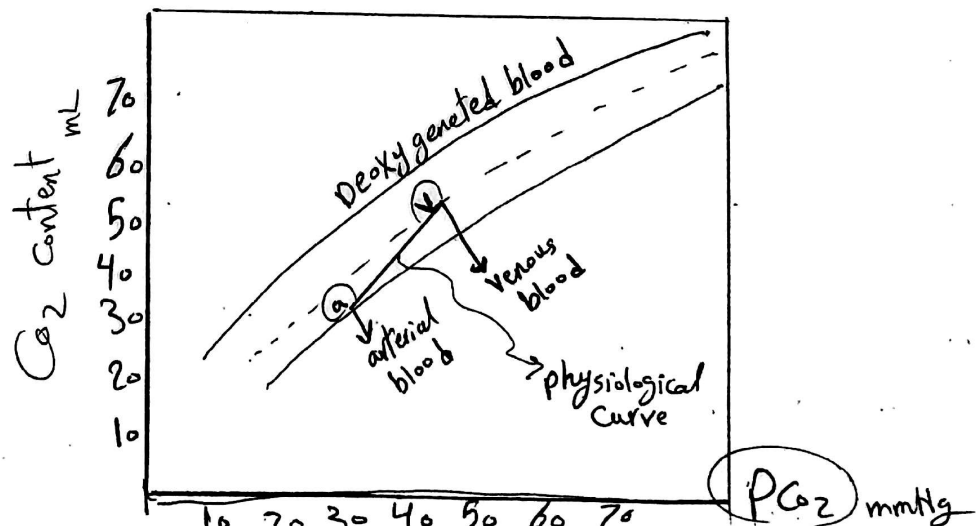
⇒ The O_2 -Dissociation Curve of Fetal Hemoglobin

- * Hemoglobin-f is found in fetal RBCs
- * The affinity of Hb-f to O_2 higher than Hb-A
- * 2-3-DPG doesn't affect Hb-f affinity to O_2



11

CO_2 Dissociation Curve



* CO_2 -Dissociation Curve shows the relationship between PCO_2 and total CO_2 content

* The curve shifts up $\odot$ down depending on the degree of Hemoglobin saturation with O_2

* Deoxygenation of $\text{HbO}_2 \uparrow$ its affinity to CO_2 and shifts the CO_2 Dissociation Curve up word
This is called (Haldane effect)

On The Curve

(A) The point which represent normal situation in arterial blood is the point on the arterial blood curve at PCO_2 40 mmHg

(V) The point which " " " " in venous blood is " " " " The venous blood curve at PCO_2 46 mmHg

→ A Line which joins 2 point is called (physiological CO_2 - dissociation curve) represents

* The changes in PCO_2 and CO_2 content which occurs in blood

⇒ In systemic capillaries The changes occur from A → V

⇒ In The pulmonary capillaries " " from V → A

12

Hypoxia

* Hypoxia (O_2 lack at tissue level)

* Hypoxemia (O_2 lack in The blood)

* Types of Hypoxia

- 1- Hypoxic
- 2- Anemic
- 3- stagnant
- 4- Histotoxic

Hypoxic hypoxia

* def (Decreased oxygen supply to tissue secondary to defective oxygenation of The blood)

* Causes

- 1- Low PO_2 in The inspired air
- 2- Defective pulmonary ventilation
- 3- Defective gas exchange

4- Shunting of blood from venous to arterial side without passing through The lung

- * Characters
 - 1- O_2 tension $\downarrow$ in The blood
 - 2- O_2 Content $\downarrow$ in The blood
 - 3- Central Cyanosis

■ Anemic hypoxia

* def (Decreased oxygen supply to The tissue secondary to defective of Hb Capable to carry O_2)

* Causes 1- Decreased Hb content of The blood as in all types of anemia

2- Presence of Non Functioning Hb as in cases of

→ (Methemoglobinemia)

(Hb) is oxidized to Met Hb which is firmly attached to O_2 and don't release it easily to The tissues

→ (Carbon monoxide poisoning)

(Co) combines with Hb at The same site of O_2 with high affinity (210 times That of O_2) Forming CarboxyHb

* Treatment of Co-poisoning

- 1- Removal of The patient from Co atmosphere
- 2- Artificial respiration

- * Characters
 - 1- O_2 tension $\downarrow$ in The venous blood only
 - 2- O_2 content $\downarrow$ in The blood
 - 3- Cherry red color of The skin

■ Stagnant hypoxia

* def (Decreased oxygen supply to The tissue secondary to stagnation of blood ($\downarrow$ blood flow rate))

* Causes

- 1- heart failure
- 2- obstruction of The blood vessels
- 3- spasms of The blood vessels

* Characters

- 1- O_2 tension and Content are normal in arterial blood
- 2- " " " " are decreased in venous blood
- 3- Central or peripheral cyanosis

14 Acclimatization to high altitude

* def This term refers to the adaptive mechanisms that occur in high altitude i.e. (prolonged exposure to low O_2 pressure)

⇒ At high Altitude

The composition of air remains constant
(but) its total pressure falls

* Acute — mountain sickness

This is a condition that may occur in some individuals when they ascend to high altitude for the first time.

- It occurs within 8-24 hours and lasts for 4-8 weeks
- Its symptoms include headache, dizziness, irritability, Fatigue, dyspnea, anorexia, nausea, vomiting
- Its cause is probably cerebral edema

* Acclimatization mechanisms

The compensatory mechanisms involved in acclimatization usually start within one week. They aim at increasing O_2 delivery to the tissues. They include the following:

① Ventilatory acclimatization

□ Increase of Pulmonary Ventilation. This occurs as a result of stimulation of the respiratory center by signals discharged from peripheral chemoreceptors.

Abdo MA ② pulmonary gas exchange adaptation. The normal diffusing capacity of O_2 through the pulmonary membrane is about 21 mL/min/mmHg.

② Increase of The blood O_2 carrying capacity

This occurs as a result of stimulation of erythropoiesis under the effect of the erythropoietin hormone.

③ increase of Circulatory rate

This occurs as a result of ① Tachycardia ② ↑ Cardiac output ③ ↑ ABP

④ increase of O_2 liberation at The tissue

This occurs as a result of stimulation of 2-3 DPG synthesis in the RBCs at high altitude.

⑤ cellular compensatory changes

It means increased ability of the cells to use O_2 despite the low P_{O_2} .